Chulitnacula, a new paleobiogeographically distinctive gastropod genus from Upper Triassic strata in accreted terranes of southern Alaska

(3 figs)

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A new protorculid gastropod genus, *Chulitnacula*, is based on *Protorcula alaskana* Smith, 1927, from the Chulitna terrane of south-central Alaska. The type species also occurs in two other accreted terranes of southern Alaska: 1.) in the Farewell terrane (Nixon Fork subterrane) of southwestern Alaska; and 2.) in the Alexander terrane of southeastern Alaska. This taxon is a common to dominant element in shallow-water, near-shore late Norian age strata of all of these terranes. It appears to be biogeographically significant in that while it so abundant in these southern Alaskan accreted terranes, it is completely unknown elsewhere in Upper Triassic para-autochthonous rocks of western North America (i.e. Nevada, Sonora). The occurrence of *Chulitnacula alaskana* (Smith, 1927) in the Chulitna, Farewell (Nixon Fork subterrane) and Alexander terranes suggests that they were in close reproductive communication in the Late Triassic. The absence of this taxon in either the Wrangellia terrane of southern Alaska and British Columbia, as well as in the related Wallowa terrane of northeastern Oregon and adjacent western Idaho is worthy of note. This absence plus many other major differences in their respective Late Triassic gastropod faunas indicate that the Chulitna-Farewell-Alexander terrane association was far removed from the Wrangellia-Wallowa terrane couplet. While both faunal associations are characteristically tropical in aspect, their biogeographically differing faunas indicate that they were probably very distantly separated from one another in the Panthalassa Ocean at this time.

Key words: Triassic, Gastropoda, Alaska, Chulitna terrane, Farewell terrane, Alexander terrane, new taxa

Introduction

On-going study by the two authors of Upper Triassic gastropod biogeography of western North America has revealed a number of biogeographically significant gastropod taxa from different accreted terranes comprising the western margin of the North American continent. Our purpose here is to demonstrate the utility of Upper Triassic gastropods as a tool in paleobiogeographic analysis of accreted terranes. Although previously poorly known from western North America (the only described faunas are to be found in Smith 1927 – Erwin 1994), this group holds great potential for biogeographic studies due to the fact that this molluscan class is well represented in faunas of these terranes. In addition, due to the very restricted nature of larval distribution in certain gastropod groups, great potential exists for the fine delineation of low-level paleobiogeographic units. This has been more than adequately exemplified by our earlier studies of Paleozoic gastropod biogeography (Blodgett 1992; Blodgett et al. 1988, 1990, 1999; Blodgett – Frýda 1999; Frýda – Rohr 1999). In this paper we draw attention to a Norian gastropod species, *Chulitnacula alaskana* (Smith, 1927), which characterizes near-shore, shallow-water marine strata of several accreted terranes (Chulitna, Farewell, and Alexander terranes) of southern Alaska (Fig. 1). In addition to indicating close spatial relationships between these three terranes within the Panthalassa Ocean during Late Triassic time, this species is also important taxonomically because it represents a new genus of the Protorculidae, which appears to include several related species in the eastern Tethys region. The newly illustrated specimens of this species are deposited in the University of Alaska Museum (UAM) in Fairbanks, Alaska, USA and in the Geological Survey (Prague), Jiří Frýda collection (CGÚ JP).

Paleobiogeographic significance

The State of Alaska is for the greater part composed of a number of tectonostratigraphic terranes (also referred to as accreted terranes, lithotectonic terranes, etc.), which have emplaced by means of sea-floor spreading and transcurrent fault movements long distances from their previous points of origin. The only exception to this is the roughly triangular portion of Alaska (Fig. 1), bounded on the northwest by the Porcupine River and to southwest by the Yukon River. The latter region represents the western terminus of the Paleozoic-Triassic North American continental margin. A number of differing terrane nomenclatures exists for Alaska (contrast Coney et al. 1980 with Jones et al. 1987 and Nokleberg et al. 1994). Triassic rocks from southern Alaska's accreted terranes contain thick carbonate successions with tropical marine faunas, in contrast to the much cooler-water Triassic faunas associated with the North American portion of Alaska (lower part of the Glenn Shale of east-central Alaska) and from the Shublik and Otuk formations of the Arctic Alaska terrane of northern Alaska. Determination of probable Triassic paleolatitudes of the southern Alaskan terranes has been the subject of many studies (Panuska – Stone 1985; Hillhouse 1977, Hillhouse – Grommé 1980, 1984; Stone 1982; Haeussler et al. 1992), many of which are contradictory to one another. Although these

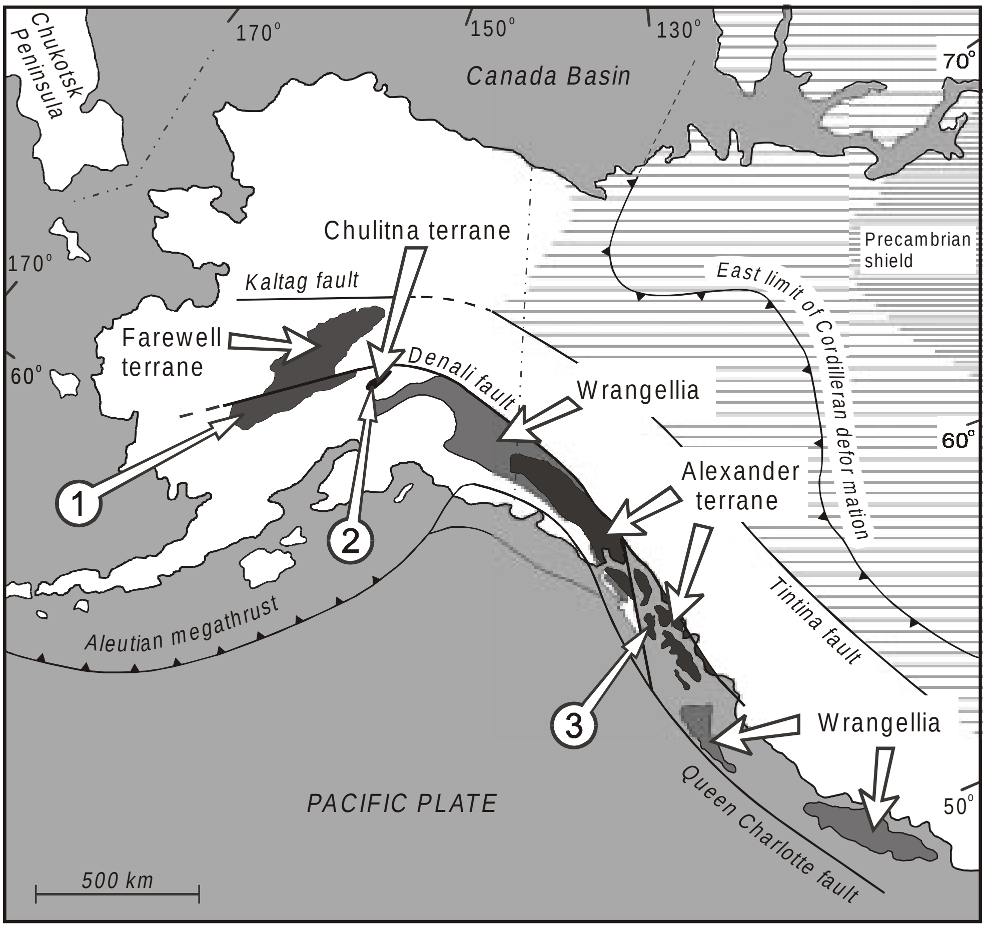

Fig. 1. Generalized map showing location of the Farewell, Chulitna, Alexander, and Wrangellia terranes in southern Alaska and northwestern Canada (modified from Coney et al., 1980). Lined pattern – North American autochthonous basement. *Chulitnacula* occurrences: 1 – Nixon Fork subterrane of Farewell terrane (Taylor Mountains D-3 quadrange); 2 – Chulitna terrane (Healy A-6 quadrangle); 3 – Alexander terrane (Port Alexander D-1 quadrangle).

accreted terranes have diverse, rich fossil Upper Triassic biotas, relatively little is known of their contained faunas with the exception of few groups such as the flat clams (Silberling 1985, Silberling et al. 1997, Grant-Mackie – Silberling 1990), bivalves in general (Newton 1983) and corals (Stanley 1979; Montanaro Gallitelli et al. 1979). In these paper our attention is focused on the biogeographic significance of one species of gastropod, *Chulitnacula alaskana* (Smith, 1927), from three separate terranes (Chulitna, Farewell, and Alexander terranes) of southern Alaska.

The Farewell terrane of southwestern Alaska (Fig. 1) was established by Decker et al. (1994) to include three previously defined terranes (Nixon Fork, Dillinger, and Mystic), which were recognized to be genetically related to one another. The latter were all reduced in rank to being subterranes of the Farewell terrane. The Farewell terrane has recently been interpreted to represent a rifted continental margin sequence derived from the Siberian paleocontinent (Blodgett – Brease 1997; Blodgett 1998; Blodgett – Boucot 1999). *Chulitnacula alaskana* (Smith, 1927) is found in Norian strata of the Nixon Fork subterrane of the Farewell terrane in the Taylor Mountains D-3 1:63,360-scale quadrangle. The Nixon Fork subterrane is characterized by a succession of strata ranging in age from Neoproterozoic to Triassic, with the Neoproterozoic-Devonian portion representing a thick succession of dominantly shallow-water carbonate rocks. Triassic strata are recognized in only two areas within the subterrane, one in the northern part in the Medfra C-3 1:63,360-scale quadrangle, and the other in southernmost part of the subterrane in the Taylor Mountains D-2 and D-3 quadrangles (Blodgett et al. 2000, McRoberts – Blodgett, in press).

This species is also very abundant in late Norian strata of the Chulitna terrane (its type area) of south-central Alaska (Fig. 1). This terrane is characterized by a distinctive succession of Upper Devonian ophiolitic rocks; upper Paleozoic chert, tuff, volcanic conglomerate and sandstone, flysch, and limestone; Triassic limestone, basalt, redbeds, sandstone and shale; and Jurassic argillite, sandstone, and chert (Jones et al. 1980). The presence of a thick redbed unit within the Triassic succession, containing late Norian fossils in uppermost strata, has been frequently cited as evidence for a more southerly origin of this terrane during Triassic time (i.e., Jones et al. 1980, 1982). Ammonites from a Lower Triassic limestone unit also indicate a more southerly origin for this terrane (Nichols – Silberling 1979). Norian age gastropods are especially common in transitional strata between the Trrb unit and overlying JTrs unit of Jones et al. (1980) in the southern part of the Healy A-6 1:63,360 scale quadrangle. *Chulitnacula alaskana* (Smith, 1927) is the most abundant gastropod in three collections made in 1997 from these two units by members of the Alaska Divison of Geological & Geophysical Surveys during mapping of this quadrangle.

Chulitnacula alaskana (Smith, 1927) is also present in late Norian strata of the Alexander terrane of southeastern Alaska (Fig. 1). This terrane includes a variety of rocks of latest Precambrian? to Middle(?) Jurassic age (Gehrels – Berg 1994). The Alexander terrane, like the Farewell and Arctic Alaska terranes of Alaska, is also considered to be of Siberian origin on the basis of its distinctive Silurian-Devonian megafauna (Blodgett – Boucot 1999). In recent years it has been suggested that the Alexander terrane and the Wrangellia terrane are part of larger tectonostratigraphic entity termed the Wrangellia superterrane or Wrangellia composite terrane (Nokleberg et al. 1994; Plafker – Berg, 1994; respectively). We find the unification of the Alexander terrane (in its type area in the Alexander Archipelago) with Wrangellia during the Late Triassic untenable on the basis of both the quite differing Triassic stratigraphies and accompaning Triassic gastropod faunas between the Alexander terrane (as expressed in the Keku Straits region between Kuiu and Kupreanof islands) and the Wrangellia terrane (see also Blodgett et al. 2001, this volume).

The genus *Chulitnacula* is unknown in either of the two major Late Triassic gastropod collections we have examined from the Wallowa (Spring Creek locality in Hells Canyon) and Wrangellia (Green Butte locality in the Wrangell Mountains) terranes, as well as from the richly diverse late Norian “Lewiston fauna” (belonging to the Wallowa terrane) from the Lapwai Indian Reservation in Idaho (Alexander Nützel, written communication, 2001). The abundant presence of *Chulitnacula alaskana* (Smith, 1927) in the three previously mentioned Alaskan terranes (Chulitna, Farewell, and Alexander terrane), compared with its absence in certain other accreted terranes (Wrangellia and Wallowa terranes) of western North America, suggest that Chulitna-Farewell-Alexander terrane assemblage was probably separated by a reproductively significant distance from the Wrangellia-Wallowa terrane couplet in differing tropical areas within the Panthalassa Ocean. We use the term assemblage here to indicate that these three terranes were close enough to one another during Late Triassic time to share similar faunas, and not that they were amalgamated with one another at this time. The separation of these terrane groupings is also supported by the overall faunal differences shown by most other gastropod groups that we have studied from these terranes.

Systematic paleontology

Subclass Caenogastropoda Cox, 1960
Order Ptenoglossa Gray, 1853
Family Protorculidae Bandel, 1991

Remarks: Cossmann (1909) placed *Protorcula* Kittl, 1894 in his family Coelostylinidae. This opinion was also followed by Wenz (1938), who considered the family Coelostylinidae to belong to the Loxonematoidea, and placed additional gastropod genera in this family, extending its stratigraphic range from the Devonian to the Jurassic. Knight et al. (1960) briefly discussed the family-level classification of Loxonematoidea. These authors divided the Loxonematoidea into four families: Loxonematidae, Palaeozygopleuridae, Pseudozygopleuridae, and Zygopleuridae; but they did not recognize the family Coelostylinidae within this superfamily. Bandel (1991) established new family Protorculidae based on the genus *Protorcula* Kittl, 1894. This family (uniting *Protorcula* and *Ampezzopleura* Bandel 1991) was placed by Bandel (1991) together with the families Zygopleuridae Wenz, 1938 and Pseudozygopleuridae Knight, 1930 into his new superfamily Zygopleuroidea. Nützel (1998) noted the paraphyly of the Zygopleuroidea and considered the Protorculidae to be an extinct sister-group of the modern Cerithiopsoidea and Triphoroidea. Nützel also changed the generic content of the family Protorculidae. The Triassic genus *Ampezzopleura* Bandel, 1991 was transferred by him from the Protorculidae to the Zygopleuridae as the genotype of a new subfamily Ampezzopleurinae Nützel, 1998, which also included the Triassic genus *Striazyga* Nützel, 1998. On the other hand, Nützel (1998) added several genera to the Protorculidae, including his new Triassic genus *Atorcula* and Jurassic genus *Acanthostrophia* Conti and Fischer, 1982. Nützel also placed with some doubt the Permian genus *Prodiozoptyxis* Batten, 1985 and the Triassic genus *Undularia* Koken, 1892 in the Protorculidae. Later Nützel and Senowbari-Daryan (1999) placed two additional Triassic genera, *Moerkeia* Böhm, 1895 and *Anulifera* Zapfe, 1962 in the family Protorculidae.

Chulitnacula gen. nov.

Type species: *Protorcula alaskana* Smith, 1927 from Norian strata of the Chulitna district (Chulitna terrane), Healy A-6 1:63,360-scale quadrangle, south-central Alaska.

Etymology: According to both the geographic feature (Chulitna River) and the tectonostratigraphic terrane (Chulitna terrane).

Diagnosis: Medium-sized protorculid with prominent keel forming angulated whorl profile; keel situated low on whorl surface, about one-fourth of whorl height above lower suture (Figs 2, 3); whorl profile above keel concave; keel bears a row of prominent nodes, varying in number from 15 to 18 per one volution in adult whorls; whorl side as well as shell base ornamented by numerous spiral threads; growth lines form a distinct wide U-shaped arch between keel and upper suture (Fig. 2.4), culminating at about one-fourth of whorl height below upper suture; growth lines below are opisthocline, crossing the keel, to reach the lower suture; shell structure and protoconch unknown.

Comparison: The new genus is most similar to the genera *Protorcula* Kittl, 1894 and *Moerkeia* Böhm, 1895. The type species of *Chulitnacula*, *Protorcula alaskana* Smith, 1927, had been placed in the former genus by

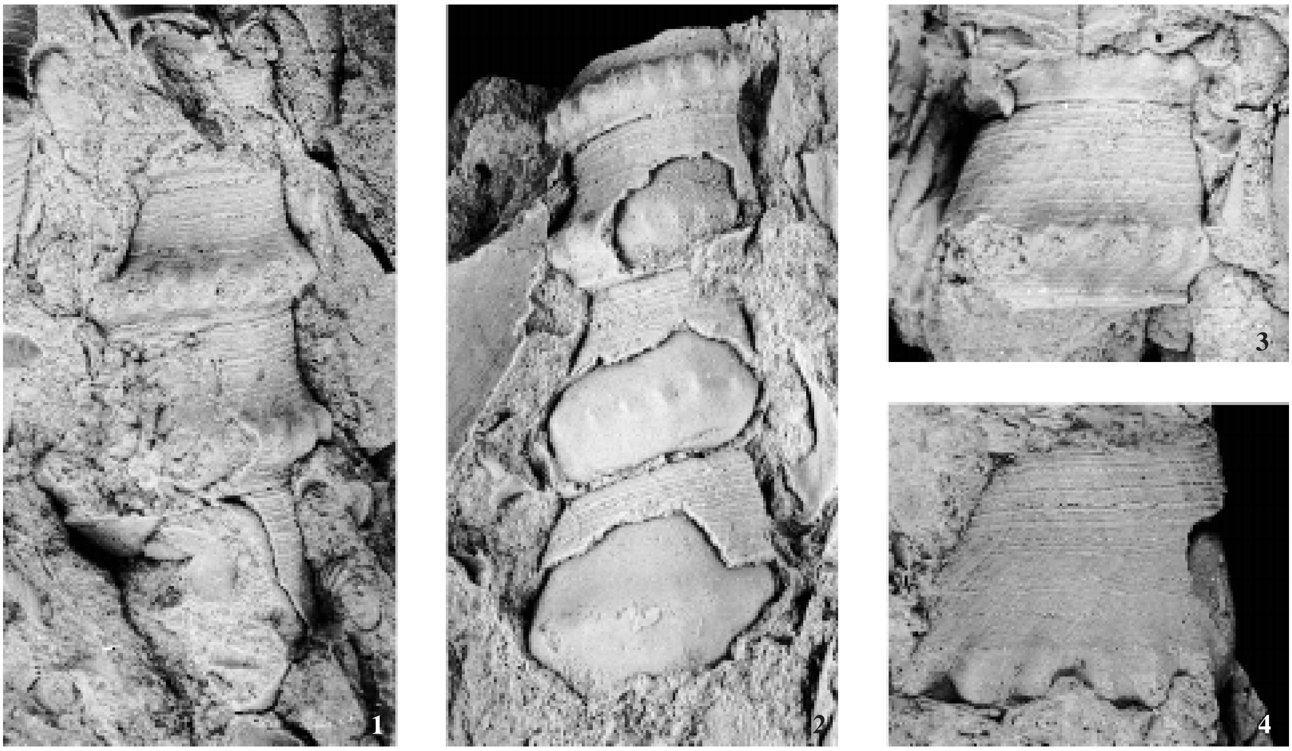

Fig. 2. *Chulitnacula alaskana* (Smith, 1927) from Healy A-6 quadrangle, south-central Alaska (Chulitna terrane); 1 – side view, UAM 2630; 2 – side view, UAM 2631; 3 – side view of final whorl, UAM 2632; 4 – side view of single whorl showing growth lines forming a distinct U-shaped apertural sinus, CGU JF785; all specimens from locality 151 of Blodgett – Clautice, 2000 (=field locality 97AM241 of Marti Miller); all views x3.

Smith (1927) and recently questionably transferred to *Moerkeia* by Nützel – Senowbari-Daryan (1999). *Chulitnacula* differs from *Protorcula* in having a different whorl profile of the teleoconch and by the absence of an upper spiral keel. In the latter genus, the whorl profile is concave between sutures and two distinctive nodose rows are developed, one close to the upper and other close to the lower suture, respectively (Zardini 1985, Pl. 4, Figs 17, 18a, b Nützel 1998, Pl. 27, Figs A–E). On the other hand, in *Chulitnacula* the whorl profile between the sutures is strongly angulated by a prominent keel bearing nodes. This keel is situated low on the whorl, about one-fourth of whorl height above lower suture. The suture in *Protorcula* lies between two distinct spiral rows bearing nodes, but such shell features close to the sutures are not present in *Chulitnacula*. In contrast, no nodose row close to the upper suture is developed in *Chulitnacula*. The external shell surface of *Chulitnacula* is ornamented by numerous fine spiral threads (Figs 2, 3), but in *Protorcula* it is smooth or ornamented by very weak spiral threads.

Chulitnacula gen. nov. differs from the type species of *Moerkeia* by its much higher spire, the absence of an umbilicus and the presence of spiral ornamentation. The genus *Moerkeia* Böhm, 1895 is based on *Angularia praefecta* Kittl, 1894 from the southern Alps of Italy. Böhm (1895) included in his new genus three additional species, which seem to be far removed from the type species (see also Nützel 1998) and their genus-level position needs further study. *Chulitnacula* may be distinguished from the protorculid genus *Atorcula* Nützel, 1998, by its angular whorl profile and shell ornamentation. Teleoconchs of all known species of *Atorcula*, including its type species, lack any angulation and the external surface of teleoconch whorls is smooth (see Nützel 1998, Pl. 26). The same shell features differentiates *Chulitnacula* from the type species of the protorculid genus *Undularia* Koken, 1892, based on the Middle Triassic *Undularia scalata* (Schlotheim) from the Muschelkalk of Germany. *Chulitnacula* also resembles the protorculid genus *Anulifera* Zapfe, 1962, in its fine spiral ornamentation as well as by the presence of a nodose spiral row situated low on the whorls of the teleoconch. However, the distinctly concave upper whorl side easily distinguishes *Chulitnacula*. The whorl side between the sutures in both known species of *Anulifera* is straight or very slightly convex, but is distinctly angular in *Chulitnacula*. The Permian genus *Prodiozoptyxis* Batten, 1985, representing probably the oldest protorculid genus (Nützel 1998), has two prominent angulations on its shell, one close to upper suture and the other close to lower suture (see Batten 1985, Figs 46–48). This shell feature distinguishes it from the new Triassic genus *Chulitnacula*.

D i s c u s s i o n : The unknown nature of the protoconch of *Chulitnacula* complicates its family-level placement. On the other hand, studies by Zardini (1978), Bandel (1991) and Nützel (1998) have provided evidence on the protoconch type of closely related forms, including *Pro-*

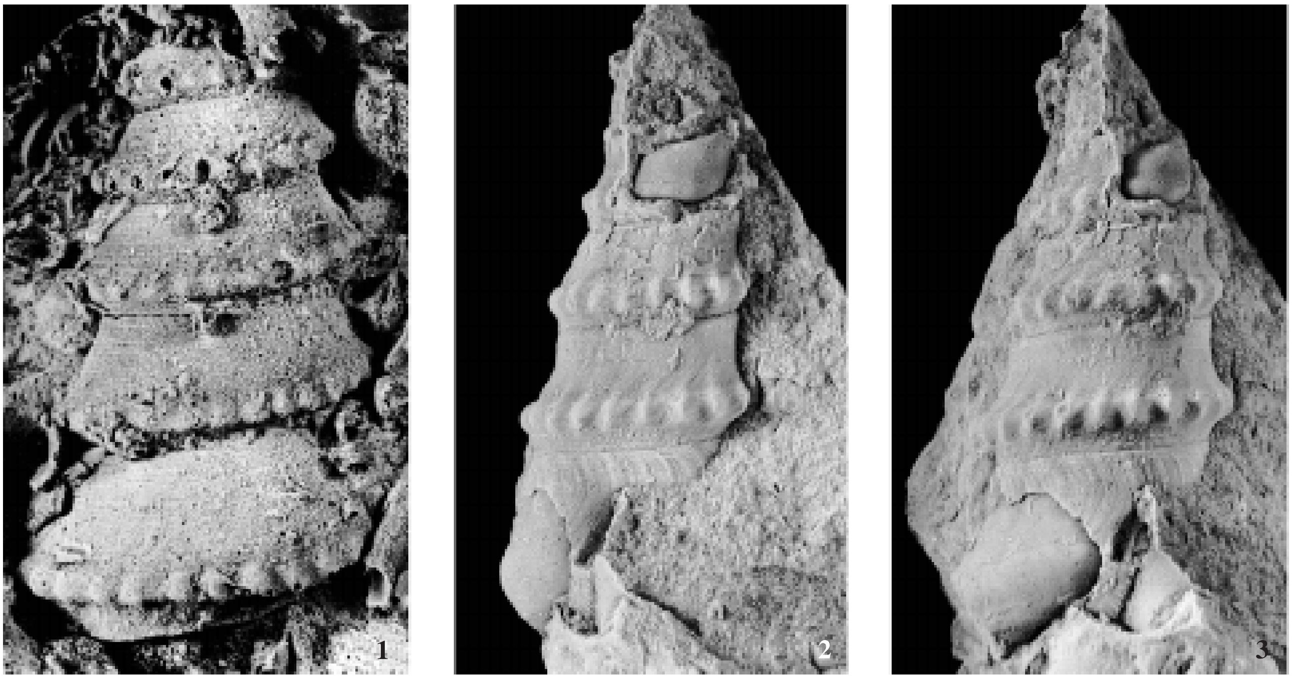

Fig. 3. *Chulitnacula alaskana* (Smith, 1927) from Chulitna (1) and Alexander (2–3) terranes; 1 – side view of latex replica of external mold (UAM 2633) from locality 118 of Blodgettt and Clautice, 2000 (=field locality 97RR149 of Rocky Reifenstuhl), Healy A-6 quadrangle, south-central Alaska (Chulitna terrane); 2–3 side views of specimen (UAM 2634) from USGS Mesozoic locality M1912 (= field locality 63Amp259 of L. P. G. Muffler) in limestone beds within the Hound Island Volcanics on Kuiu Island, Port Alexander D-1 quadrangle (Alexander terrane); all views x3.

torcula, the type genus of the family Protorculidae. The presence of many common shell features between *Chulitnacula* and the protorculids, such as similar size, general shell shape and ornamentation, strongly suggest placement of *Chulitnacula* in the family Protorculidae. This taxonomic position is also supported by the presence of spiral ornament on the shell base, considered by Nützel – Senowbari-Daryan (1999) to represent a typical protorculid shell feature.

Included species: Gastropod species previously placed in genus *Protorcula* are known from many areas (Italy, Iran, Indonesia, Alaska) and are in need of a new revision. The new genus *Chulitnacula* is based on one of them and probably unites several previously described gastropod species, earlier assigned to the genus *Protorcula*. The whorl shape of *Chulitnacula* is far removed from the type species of *Protorcula*, *Protorcula subpunctata* (Münster, 1841), and both genera may easily be distinguished from one another. Unfortunately, it is difficult to make a complete list of species possibly belonging to *Chulitnacula* on the basis of their illustrations, because in many cases they are of poor quality. Nevertheless, *Protorcula bassetti* Smith, 1927 from Late Triassic strata on Gravina Island, southeastern Alaska, *Protorcula parvula* Krumbeck, 1913, from Indonesia, and *Promathilda (?) jenningsi* Douglas, 1929, from Iran most probably belong to *Chulitnacula*. The latter species was recently transferred to genus *Moerkeia* Böhm, 1895 by Nützel and Senowbari-Daryan (1999), who noted that "this species differs in some respects from the type species of the genus *Moerkeia*" (Nützel – Senowbari-Daryan, 1999, p. 116). However, this species seems to be very close to the type species *Chulitnacula alaskana*. The Iranian *Moerkeia jenningsi* (Douglas, 1929) differs from *Chulitnacula alaskana* in having a wider sinus and a less nodose keel in adult whorls (Nützel – Senowbari-Daryan, 1999, Pl. 4, Fig. 8). In addition, the almost identical shape of the younger whorls of the teleoconch of *Moerkeia jenningsi* (Nützel – Senowbari-Daryan, 1999, Pl. 4, Fig. 6) and *Chulitnacula alaskana* strongly argues for its placement in the genus *Chulitnacula*.

Chulitnacula alaskana (Smith, 1927) comb. nov.

1927 *Protorcula alaskana* Smith, p. 109, Pl. 103, Figs 9–10.

Description: Medium-sized, high-spired, slender protorculid shell; restored height of largest specimen minimally about 4.0 cm; whorls slightly wider than high; whorl profile distinctly angulated by prominent keel situated low on whorl (about one-fourth of whorl height above lower suture); keel bears nodes, numbering from 15 to18 per adult whorl; upper whorl surface above keel distinctly concave; sutures shallow, but distinct; another, much lower keel situated just on boundary between lateral and basal sides of whorl; latter keel rounded and lacks nodes; whorls join at this keel; shell base conical, containing an angle about 45° with shell axis; growth lines form distinct wide, U-shaped arch (sinus) between lateral keel and upper suture, culminating about one-fourth of whorl height below upper suture; growth lines opisthocline below sinus, crossing keel to lower suture, and continuing onto shell base; ornament consists of numerous, fine spiral threads which cover lateral and basal whorl sides; shell structure and protoconch unknown.

Occurrence: The type material of *Chulitnacula alaskana* (Smith 1927) is from the Chulitna terrane of south-central Alaska and was collected on July 15, 1917, by S. R. Capps of the U. S. Geological Survey, who was leading a USGS geological field mapping party in the upper Chulitna region. The locality cited by Smith is USGS Mesozoic locality 10093, which is noted as "Copeland Creek at Camp July 14" (Smith 1927, p. 109). This locality which consists of stream gravels along Copeland Creek is situated in the Healy A-6 1:63,360-scale quadrangle. Further information on this locality can be found in Martin (1926, p. 44) who cites this locality as being a "stream bar of Copeland Creek." Subsequently, Smith (1927) in his monograph on Upper Triassic faunas of western North America named the species *Protorcula alaskana* based on material collected by Capps at USGS Mesozoic locality 10093, and indicated this species to be of probable Carnian age. Two specimens were illustrated by Smith (1927, Pl. 103, Figs 9, 10), with the holotype being designated as the specimen illustrated in figure 9. During the 1997–1998 field mapping effort of the Alaska Division of Geological & Geophysical Surveys in the Healy A-6 1:63,360-scale quadrangle of south-central Alaska, new material of this species was discovered at three localities (localities 118, 120, and 151 of Blodgett – Clautice 2000). Specimens from locality 151 (collected in 1997 by Marti Miller of the U. S. Geological Survey, her field number 97AM241) are conspecific with *Chulitnacula alaskana* and several of these are illustrated here (Fig. 2). This locality is located on the slightly flattened part of the ridge just below the break in slope that occurs between the 5000 and 5100 foot contour lines in the SW¼ of the SW¼ of the SE¼ of Section 2, T22S, R13W of the Healy A-6 1:63,360-scale quadrangle. This locality according to Miller (written commun. 1997) is in the lowermost beds of the JTrs unit of Jones et al. (1980). Several tens of meters stratigraphically below this locality is the transistional contact with the underlying Trrb unit of Jones et al. (1980). The morphological type of the hydrozoan *Heterastridium* present in the transistional zone between these two units indicates a late Norian age for this interval (George Stanley, personal communicatio). One specimen from locality 118 (collected in 1997 of Rocky Reifenstuhl of the Alaska Division of Geological & Geophysical Surveys, his field number 97RR149) is illustrated here (Figs 3-1). This locality is from the JTrs unit and is situated slightly above the center of the SW¼ of Section 8, T21S, R12W of the Healy A-6 1:63,360 scale quadrangle.

Chulitnacula alaskana (Smith) also has been found in a Norian age limestone unit in the Nixon Fork subterrane of the Farewell terrane of southwestern Alaska. These specimens were recovered from a single locality, sampled by Blodgett during two separate years: his locality 84RB32 (which is the same as his 99RB35). The geographic coordinates for this locality is the SW¼ of the NE¼ of the NW¼ of Section 19, T10N, R42W of the Taylor Mountains D-3 1:63,360-scale quadrangle. These specimens were recovered from a band of silicified fossils at the east end of a prominent rubble crop exposure visible from the air composed of yellow-orange weathering, platy silty lime mudstone. The fauna from this locality was briefly listed in Blodgett et al. (2000) and the bivalves and gastropod molluscs from the locality are described by McRoberts – Blodgett (in press). Molluscs dominate the fauna from this locality and include approximately 11 species of gastropods. *Chulitnacula alaskana* is represented here by nine specimens that represent the largest sized gastropod species in the collection. The teleoconch of this species closely compares with the Chulitna terrane material in general shape, however, the coarsely silicified character of the Farewell terrane material did not allow for preservation of the finer spiral elements of ornamention.

Chulitnacula alaskana (Smith) also is present in the Alexander terrane of southeastern Alaska. It has been observed by us (Figs 3.2, 3.3) at a single locality collected by N. J. Silberling and L. P. J. Muffer in 1963 (USGS Mesozoic locality M1912; = field locality 63Amp259 of L. P. G. Muffler of the U. S. Geological Survey) from limestone beds within the Hound Island Volcanics on Kuiu Island in the Port Alexander D-1 1:63,360-scale quadrangle. This locality is shown as locality 29 on geologic map of Muffler (1967, Pl. 1, locality 29). According to Muffler (1967, p. C43), this locality is situated on a cove 2 miles north of the west end of Kadak Bay on Kuiu Island and is of late Norian age. Additional information on the locality is provided by the USGS locality register which gives the following "North shore of tidal inlet directly west of triangulation station "Luck" from limestone overly Triassic volcanics. 17,750 feet S7˚E from triangulation station "Low."

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